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INSTRUCTION MANUAL

MODELS 503, 503C

MILLIOHMMETERS

KEITHLEY INSTRUMENTS, INC.

INSTRUCTION MANUAL

MODELS 503, 503C

MILLIOHMMETERS

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We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, DDD 216-248-0400. You will be given assistance and shipping instructions.

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To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

TABLE OF CONTENTS

	Page
Section I. Introduction. . . .	1-1
Section II. Specifications . .	2-1
Section III. General Description.	3-1
A. Applications.	3-1
B. Measurement Technique . .	3-1
C. Accuracy.	3-1
D. Repeatability	3-1
E. Calibration	3-1
F. Voltmeter Specifications.	3-2
G. Test Current Characteristics.	3-2
H. Speed of Measurements . .	3-2
I. Warm-Up	3-2
J. Recording	3-2
K. Power Requirement	3-2
L. Rack or Cabinet Mounting.	3-2
Section IV. Operation.	4-1
A. Description of Controls and Terminals	4-1
B. Outline of Procedure. . .	4-2
C. Calibration.	4-3
D. Recording	4-3
E. Measurement of Grounded Samples.	4-3
F. Accuracy Considerations.	4-4
G. Instructions of Rack Mounting. . .	4-7
Section V. Circuit Description.	5-1
A. Power Supply	5-2
B. Test Current Generator	5-5
C. AC Vacuum Tube Voltmeter	5-5
D. Synchronous Demodulator.	5-6
Section VI. Servicing Information . . .	6-1
A. Trouble Shooting Guide	6-1
B. Calibration.	6-3
Section VII. Replaceable Parts.	7-1
A. Replaceable Parts List	7-1
B. How to Order Parts	7-1
Models 503, 503C Replaceable Parts List	7-2
Model 5031 Replaceable Parts List.	7-6
Model 503 Schematic Drawing 14628D	7-9
Green Calibration and Repair Forms	7-11
* Change Notice	Last Page

* Yellow Change Notice sheet is included only for instrument modifications affecting the Instruction Manual.

SECTION I - INTRODUCTION

The Keithley Model 503 Milliohmmeter is designed to measure low value resistances from 0.001 ohm, full scale, to 1000 ohms, full scale. It is line powered and direct reading and has a provision for chart recording.

It is capable of an accuracy of 1% of full scale for meter indications and 0.5% of full scale for the output voltage.

An AC measuring system is employed to minimize test current through the test sample and at the same time realize drift free operation. This technique also eliminates errors due to thermal EMF's.

The instrument is completely self contained and includes test leads (Model 5031) for connection to the sample. It is readily convertable to either bench or rack mounting.

FIGURE 1. Model 503 equipped for bench use.

SECTION II - SPECIFICATIONS

RANGE, ohms	Applied Current, milliamperes rms	Voltage Drop, microvolts rms	Maximum Dissipation in Sample, microwatts
0.001	100	100	10.0
0.003	33.0	100	3.30
0.010	10.0	100	1.0
0.030	3.30	100	0.33
0.10	1.0	100	0.10
0.30	0.33	100	0.033
1.0	3.0	3000	9.0
3.0	1.0	3000	3.0
10	0.30	3000	0.9
30	0.10	3000	0.3
100	0.03	3000	0.09
300	0.01	3000	0.03
1000	0.003	3000	0.009

ACCURACY:
Meter: ±1% of full scale on all ranges.
Output Terminals: ±0.5% of full scale on all ranges.
Note: Less than 1% error is added in measuring samples with a series reactance less than 2% of sample resistance.

ZERO DRIFT: None.

WARM-UP TIME: 15 minutes.

INPUT ZERO: Lever switch prevents off-scale meter indications while changing samples.

RISE TIME (10% to 90%): 0.25 second on all ranges.

SAFETY: Maximum power dissipation in sample with improper range setting is 80 milliwatts. Maximum dissipation caused by instrument component failure and improper range setting is 160 milliwatts.

REPEATABILITY: Within 0.25% of full-scale range setting.

CALIBRATION: Internal resistance standard for calibration with front panel controls.

RECORDER OUTPUT:
Output: ±100 millivolts dc at full scale.
Output Resistance: 800 ohms.
Noise (above 10 cps): Less than 1 millivolt rms.

CONNECTORS: Test Leads: Cannon XLR-3-32. Output: Amphenol 80-PC2F.

POWER: 105-125 or 210-250 volts, 50-1000 cps, 30 watts.

DIMENSIONS, WEIGHT: 5-1/2 inches high x 17-1/2 inches wide x 13-1/2 inches deep; net weight 18 pounds.

ACCESSORIES SUPPLIED: Model 5031 Current and Voltage Leads; mating output connectors.

SECTION III - GENERAL DESCRIPTION

A. APPLICATIONS: The Keithley Model 503 Milliohmmeter is especially useful for accurate measurement of low value resistors; resistances of lead wires, terminal connector contacts and welds; resistance change in conductors due to temperature and humidity effects; resistance of ohmic junctions in semiconductors; resistivity of semiconductors, contact resistance of vibrators, relays and choppers and internal resistance of dry cells. Also for resistivity profiles of thermoelectric materials and safe measurement of squibs and fuses.

B. MEASUREMENT TECHNIQUE:

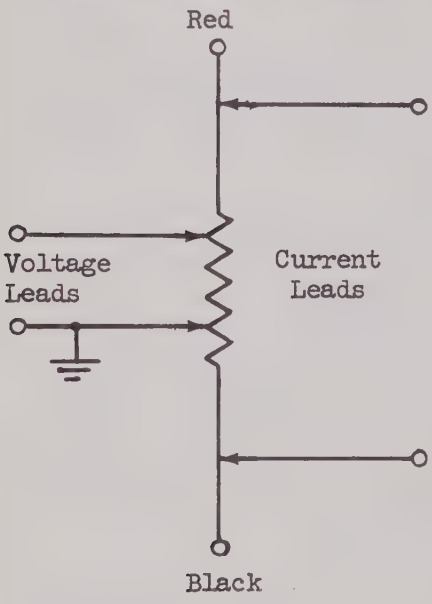


Figure 2

The Model 503 measures resistance by an ammeter-voltmeter method using an ac test current. Four terminals are employed; two furnish a known test current to the sample and two measure the resultant voltage drop.(Fig. 1) The voltage is measured by a synchronous ac voltmeter sensitive only to the test current frequency.

Most Kelvin resistance methods employ dc current to measure resistance. This method has the advantage of measuring only the resistive portion of the sample. However, due to the extremely low resistance being measured either extremely high currents must be passed through the sample or very high sensitivity dc voltmeter techniques must be used to measure the voltage drop across the sample. In the case of high current operation (which is the more common) excessive heating and damage to the sample may occur. If high sensitivity DC voltage measurement is used, extreme inaccuracy may occur because of thermal EMF's and other spurious dc disturbances. With the AC method used in the Model 503, there exists some possibility of error due to the reactive component of the sample (Section IV-F) although in most cases at 40 cps testing frequency this is negligible. However, with an ac exciting test current, thermal EMF's are eliminated and very stable high sensitivity measurements can be made so that with this AC method sample dissipation can be held 10 microwatts in measuring a 1 milliohm sample. (Table 1 - Specifications) A typical dissipation on a DC Kelvin Bridge is 1 watt for the same measurement.

C. ACCURACY: The accuracy of the measurement can be dependent on several factors. These are discussed in Section IV-F. The basic accuracy of the 503 is within 1% of full scale for meter indications and 0.5% for full scale output voltage.

D. REPEATABILITY: Having once established a reading for a particular sample measurement, it is possible to repeat within 0.25% of the full scale range setting. This assumes the connections to the sample remain fixed.

E. CALIBRATION: The 503 is self calibrating and thus reduces the need for resistance standards to check its accuracy. It is possible to verify the calibration with or without the sample attached to the test leads. (See Sect. IV-C)

F. VOLTMETER SPECIFICATIONS: Since the 503 uses a synchronous demodulator, the voltmeter is sensitive only to signals of the test current frequency. The sensitivity and input impedance are listed in Table 2.

TABLE 2

Ranges	Rms Input for Full Scale Deflection	Z in
Milliohm	100 uv	200 ohms
Ohm	3000 uv	1×10^6 ohms

G. TEST CURRENT CHARACTERISTICS: The test current is a square wave derived from the transistor inverter. The frequency is about 40 cps, and can be adjusted as discussed in Section V-B. This may be desirable if the power line frequency is a multiple of 40 cps.

The maximum open circuit voltage is no more than 20 volts peak to peak. No more than 80 milliwatts of power can be delivered from this source.

H. SPEED OF MEASUREMENT: Fast measurements are possible by virtue of an overall 0.25 second response (90% full scale) of the output voltage. A zero switch on the front panel shorts the input to the voltage amplifier, thus preventing off scale indication while changing samples. Recovery from overload is almost instantaneous and normal operation can be immediately resumed.

I. WARM-UP: Operation within the stated specification is assured if the 503 has a 15 minute period of warm-up. It can be used within one minute, but measurements may not be within the accuracy specification.

J. RECORDING: Output terminals are available at the rear of the instrument. The output is +100 millivolts across approximately 800 ohms. The output noise level, above 10 cps, is less than 1 millivolt rms. This output is suitable for driving digital voltmeters and servo-rebalance recorders. The accuracy of the output is 0.5% of full scale.

K. POWER REQUIREMENT: The Model 503 can be powered over a range of line frequencies from 50 cps to 1000 cps. The line voltages can range from either 105 to 125 volts or 210 to 250 volts. No special connections or modifications are required to operate over the range of power line frequencies.

A three prong power line cord is provided, this is to assure proper grounding of the instrument to the power line.

L. CABINET OR RACK MOUNTING: The Model 503 is shipped as a bench instrument unless the order calls for rack-mounting. The Model 4000 Rack Mounting Kit adapts the instrument for standard 19-inch rack mounting. Refer to paragraph IV-G for conversion instructions.

SECTION IV - OPERATION

A. DESCRIPTION OF CONTROLS AND TERMINALS:

1. RANGE SELECTOR: The RANGE SELECTOR has six milliohm positions ranging from 1 milliohm to 300 milliohms, and seven ohm positions ranging from 1 ohm to 1000 ohms. A CAL position is provided for instrument calibration. (Fig. 3)

2. ON: Toggle switch is the main power switch. Presence of power is indicated by the illuminated front panel pilot lamp. (Fig. 3)

3. OPERATE-ZERO: This is a lever switch. With the switch in the up (operate) position the 503 is ready to take measurements. In the down (zero) position the 503 is in zero check. (Fig. 3)

4. CALIBRATE: This control is used to calibrate the meter and the output voltage of the 503. It is a recessed slotted control that can be adjusted with a screw driver. (Fig. 3)

5. VOLTAGE TERMINALS: A 3-pin male receptacle is used for connection to the voltmeter circuit. Pin No. 3 is at chassis ground. Either test lead can be plugged into this receptacle. (Fig. 3)

6. CURRENT TERMINALS: A 3-pin male receptacle is used for connection to the current source. Either test lead can be plugged into this receptacle. (Fig. 3)

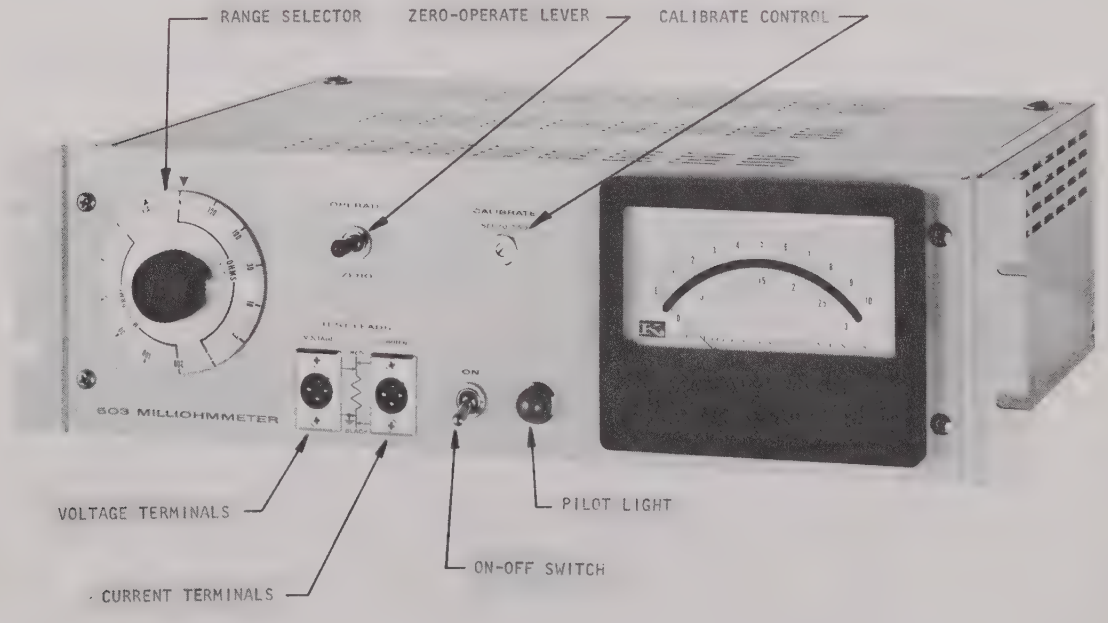


FIGURE 3. Model 503 Controls.

7. OUTPUT: A two terminal receptacle is located at the rear of the chassis. This provides the output voltage for recording. Pin No. 2 is at chassis ground.

8. RESET (503C ONLY): This unlocks the contact circuit. A 9-pin receptacle at the rear of the chassis provides connections for operation with the contact meter.

9. OUTPUT CAL: This is a slotted control located inside the instrument on the chassis behind the front panel. This adjusts the value of the output voltage for a full scale reading.

10. MILLIOHMS CAL: This is a slotted control located inside the instrument on the chassis behind the front panel. The milliohm ranges are calibrated using this control. A low resistance standard is required for its use. This is a factory adjusted control and should not require attention.

11. FUSE: A fuse extractor post is located on the rear of the instrument. For 117 volt operation use a 3 AG, $\frac{1}{2}$ amp fuse; for 234 volts use a 3 AG, $\frac{1}{4}$ amp.

12. POWER CORD: The three-wire cord with the NEMA approved three-prong plug provides a ground connection for the cabinet. An adapter to allow operation from two prong outlets is provided.

B. OUTLINE OF PROCEDURE:

1. Connect power cord to power source. A three-wire power cord is furnished with the 503. Power line voltage and frequency range are specified on the rear of the instrument.

2. Set ZERO-OPERATE lever to the ZERO position. Set RANGE SELECTOR to 1000-ohm position.

3. Turn on the power. Allow 15 minute warm-up.

4. CONNECTIONS: Each test lead set has two clips, one with a red insulator and the other with a black insulator. When making connections use both test leads, making sure clips with like color insulators are on the same side of the sample. (Refer to Figure 2) This is necessary to avoid meter readings below zero.

a. Four terminal connections: The current leads should be attached to the sample making sure the test current flows through the entire sample. This may include leads on the sample. Attach the voltage leads being sure they are connected only across that portion of the sample to be measured. If the terminals or the leads of the sample are included in the voltmeter circuit, their resistance will be included in the reading. (See Section IV-F)

b. Two terminal connections: This type connection is made by attaching together voltage and current clips having like color insulators and measuring across the sample. (Fig. 4) This type connection is permissible when measuring samples above 3 ohms. (See Section IV-F)

5. OPERATION: With the sample connected, set the ZERO-OPERATE switch to OPERATE, rotate the RANGE SELECTOR until a deflection is observed. Thus, if the RANGE SELECTOR is set at 100 milliohms and a reading of 6.3 is taken, the value of sample resistance is 63 milliohms.

If the sample is part of a system, attention should be given to the grounding of the sample. The voltage lead with the black insulator is the ground lead of the 503. (See Section V-D)

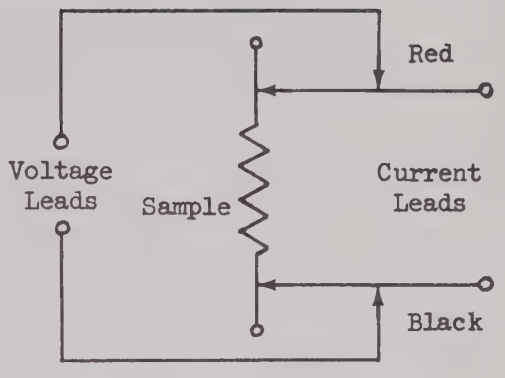


FIGURE 4. Two-terminal connection.

6. REMOVING THE SAMPLE: Place the OPERATE-ZERO switch in ZERO position and remove the sample.

C. CALIBRATION: Place the selector switch in CAL position. Set the OPERATE-ZERO switch to OPERATE position. Turn the slotted CALIBRATE control for needle deflection to 7.50 on the meter. The instrument can be calibrated independently of the test leads connected. (See Section VI-B)

D. RECORDING: Connect to the output terminals, observing that pin No. 2 is at ground. The 503 is designed to drive a 100 millivolt recorder. The CALIBRATE control on the front panel calibrates the output as well as the meter. An internal control R125 OUTPUT CAL is adjusted at the factory to insure tracking between the meter and the output voltage. (See Figure 14)

If it is desired to use a recorder other than 100 millivolts, the output terminals may be shunted with the following values:

Recorder Sensitivity	Resistance Value
50 mv	360 ohms
10 mv	80 ohms
1 mv	360 ohms (tap output 7 ohms from ground)

After the divider is added to the output, recalibrate the instrument on the CAL position. Adjust recorder sensitivity with R125, the internal recorder CAL control.

E. MEASUREMENT OF GROUNDED SAMPLES: It is possible that the test sample may be independently grounded at some point. Since the voltage test lead with the black clip insulator is at chassis ground, errors could arise in measurement.

1. TEMPORARY MEASURE FOR OCCASIONAL MEASUREMENTS: Isolate the Model 503 using a two-prong power cord adaptor to remove the ground connection to the power line. Place the instrument so that the cabinet is not touching ground. If the tilt bail is not used, the rubber feet can provide the proper insulation.

2. PERMANENT SET-UP: Should it be necessary to unground the chassis, (such as in rack use) the following modification will facilitate such measurement. The change allows the instrument to operate only on the milliohm ranges; the ohm ranges are inoperative.

Remove the chassis ground connection from pin 4 of T-1 and pin 3 of J-1. Then connect pin 3 of J-1 to pin 4 of T-1. In this way both the voltage and current test leads will be isolated from ground. (Fig. 5)

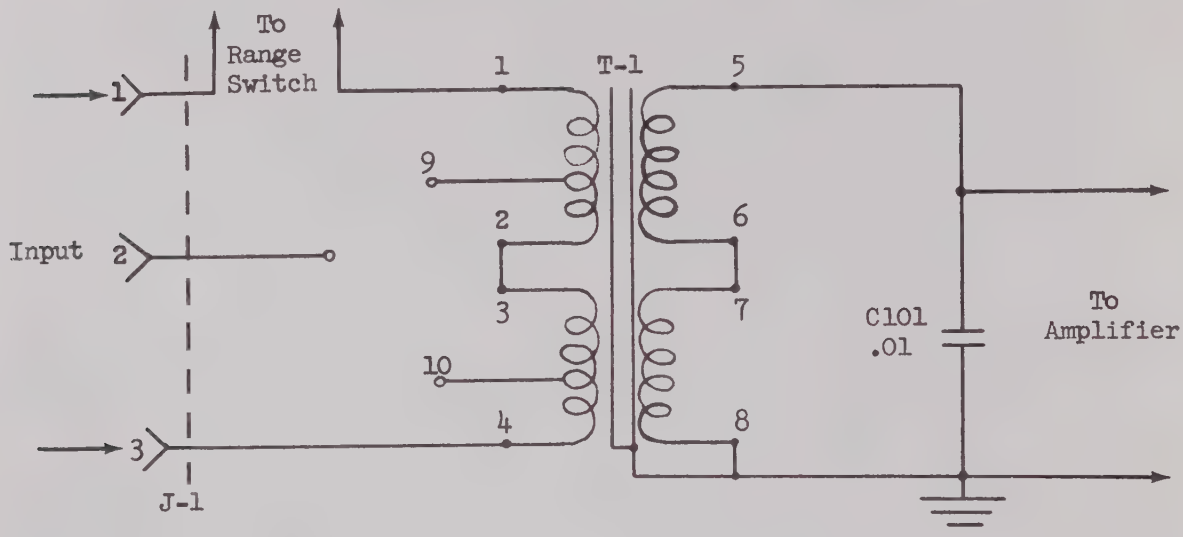


FIGURE 5. Modification for unground chassis.

F. ACCURACY CONSIDERATIONS:

1. MEASUREMENT IN THE PRESENCE OF DC CURRENTS: The 503 can measure resistance with dc currents present in the sample. An influencing factor is the amount of current that will saturate the voltmeter input transformer. A 1% error in measurements, using milliohm range settings, will occur if the dc current causes a 20 millivolt drop across the sample. The dc current through the sample can be increased if a capacitor is put in series with a voltmeter lead. The capacitor should be 10,000 ufd with a voltage rating greater than the dc current source voltage.

With measurements in the range from 1 ohm to 1000 ohms, a 1% error will occur if a current greater than 1 milliampere flows through the current supply circuit. The voltmeter will not be effected unless the source voltage of the dc current exceeds 50 volts.

The dc sample current which will cause 1 ma to flow in the current supply circuit may be computed from the sample resistance and the range resistor in use.

2. INDUCTIVE AND CAPACITIVE EFFECTS: The Model 503 uses an ac measuring system and synchronous demodulation to discriminate against 60 cycle pick-up and to discriminate to a degree against reactive components in the sample. Therefore, usually, no special precautions or shielding are necessary unless

the ac fields in the neighborhood of the sample are unusually strong. The usual cause of trouble will be due to electro-magnetic induction. Electrostatic pick-up usually is no problem at the impedance involved. A good way to test for pick-up is to remove the current leads and leave the voltage leads attached to the sample. If no reading is seen, there is no cause of concern. If, however, there is a reading, the source of magnetic field must be removed or the sample oriented in such a way as to minimize the reading.

Because of the ac technique employed, inductive and capacitative components in the test impedance may cause some wave-form distortion and erroneous readings. In practice, it has been found that the following method will enable the user to calculate errors introduced by inductance in series with the sample or capacitance across it. Experimentally it can be shown that the error due to a series inductance or shunting capacitance is equal to about 50% of what would be calculated, assuming the shunting or series effect was due to the impedance computed for a 40 cps sine wave.

In the presence of large interfering ac fields, some needle flutter will be noted. This will be due to a beat between the 40 cps carrier frequency and the signal. The average value of the pointer indication will be the correct reading unless the interfering signal is exactly equal in frequency to the carrier. In this case large errors may be encountered. However, since a 40 cps interfering signal is rarely encountered, there will be little likelihood of trouble.

Coupling between the current and voltage leads can cause significant error on the 1 milliohm range. This can be minimized by keeping the voltage and current leads separated and by twisting the pairs of leads to reduce the enclosed area.

3. ERRORS DUE TO SERIES RESISTANCE IN CURRENT AND VOLTAGE LEADS: Series resistance may be appreciable in such cases as resistivity profile measurements, or when low resistance connections to the sample cannot be made. (See Fig. 6)

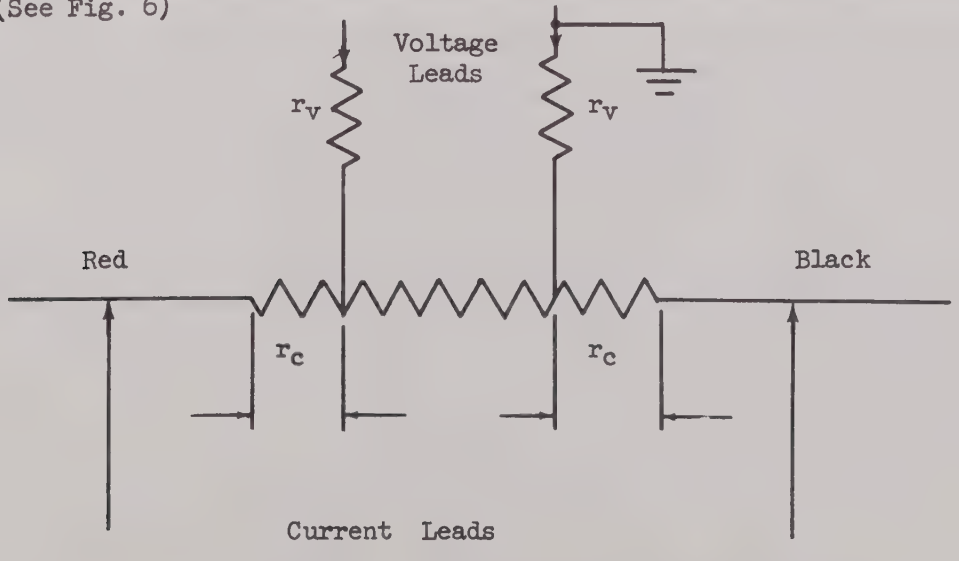


FIGURE 6. Series Resistance Measurements

TABLE 3

The tabulated values will give no more than 1% error in measurement:

Range	Total resistance in current leads $2r_c$	Total resistance in voltage leads $2r_v$
Milliohm range settings	1000x full scale range setting	1 ohm
Ohm range settings	33x full scale range setting	10K ohms

G. PREPARATION FOR RACK MOUNTING. (See Figure 7.)

1. The Model 503 is shipped for bench use with four feet and a tilt-bail. The Model 4000 Rack Mounting Kit converts the instrument to rack mounting to the standard EIA (RETMA) 19-inch width.

Item (See Figure 7.)	Description	Keithley Part No.	Quantity
1	Cover Assembly	14623B	1
2	Cover Assembly, Bottom (Supplied with Model 503)	14590B	1
3	Angle, Rack	14624B	2
4	Screw, Phillips Head, 10-32 UNC-2x$\frac{1}{4}$ (Supplied with Model 503)	--	4
5	Front Panel (Supplied with Model 503)	--	1

TABLE 4. Parts List for Model 4000 Rack Mounting Kit.

2. To convert the Model 503, remove the four Phillips head screws at the bottom of each side of the instrument case. Lift off the top cover assembly with the handles; save the four screws. To remove the feet and tilt bail from the bottom cover assembly, turn the two screws near the back. The two pawl-type fasteners will release the cover and allow it to drop off. Remove the feet and the tilt bail and replace the cover (2).

3. Attach the pair of rack angles (3) to the cabinet with the four Phillips head screws (4) previously removed. Insert the top cover assembly (1) in place and fasten to the chassis with the two pawl-type fasteners at the rear. Store the top cover with handles, feet and tilt-bail for future use.

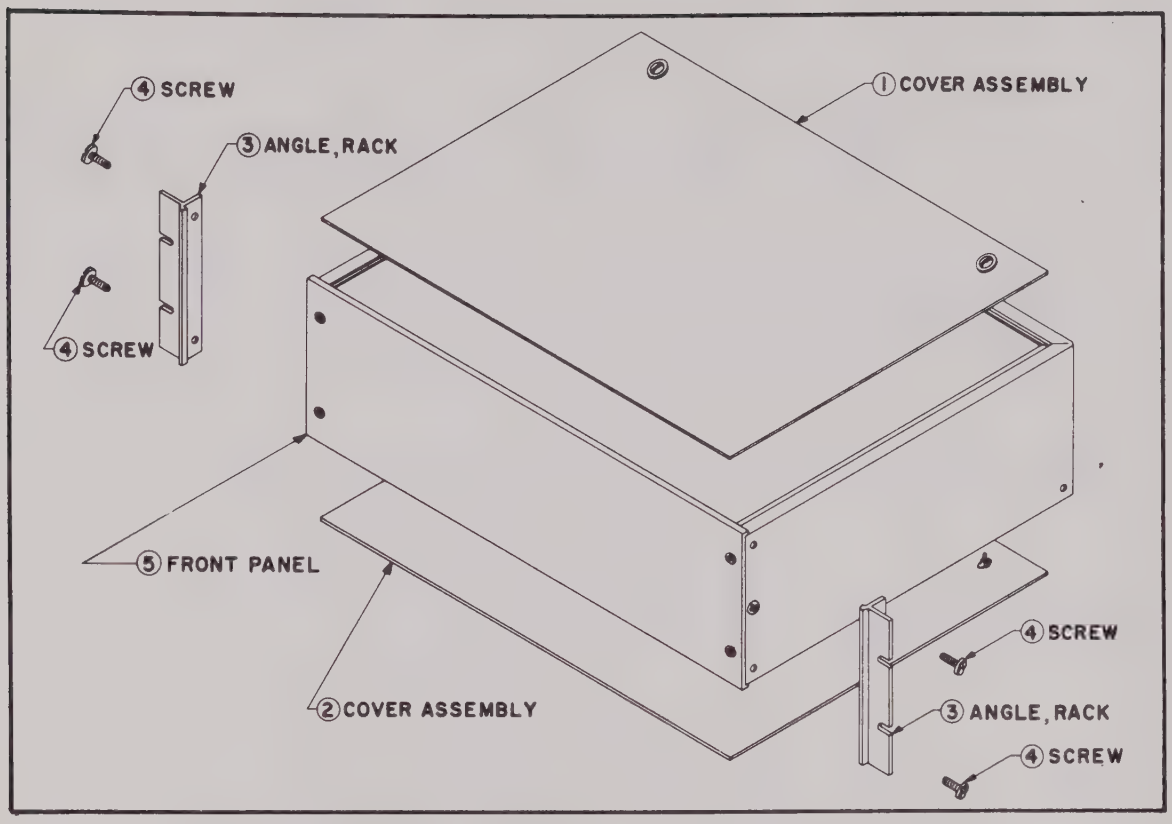


FIGURE 7. Exploded View for Rack Mounting.

SECTION V - CIRCUIT DESCRIPTION

The Model 503 circuit consists of four basic sections; a twelve volt super-regulated power supply, a transistor dc to ac inverter circuit, a four stage high gain vacuum tube amplifier and a silicon diode demodulator.

The twelve volt power supply operates from the line voltage and furnishes a very closely regulated 12 volts. This voltage is used to light the tube filaments and to operate the transistor converter. The converter operates at 40 cps. The output obtained from the converter transformer via various windings, operates the demodulator diodes, supplies the 40 cps test current and the B-plus supply for the ac amplifier via a rectifier-filter system.

The vacuum tube amplifier operates following an input transformer on the milliohm ranges and directly amplifies the signal on the ohm ranges. A high degree of gain stability is assured by a substantial feed-back factor and by the use of closely regulated plate and filament supplies.

The output of the amplifier is synchronously demodulated by a silicon diode bridge and the resulting dc signal operates the output circuit and the meter.

A detailed circuit description follows:

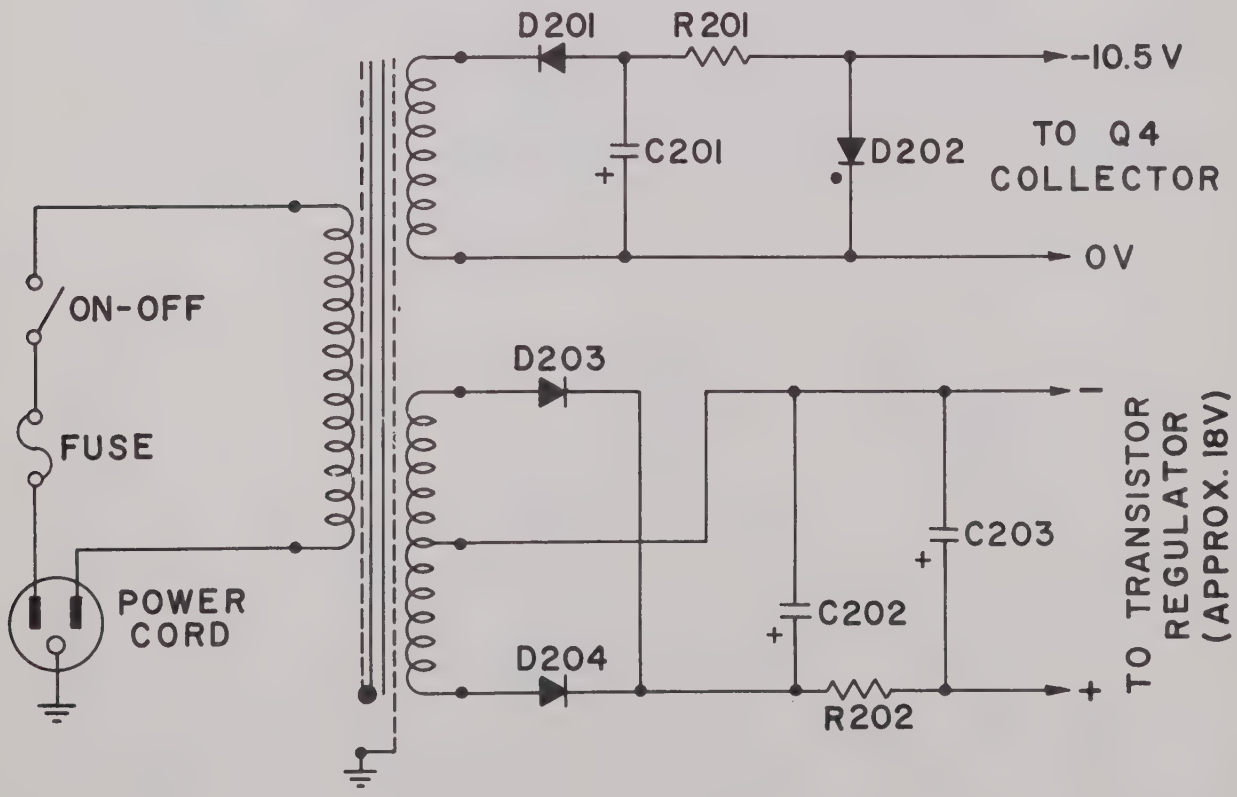


Figure 8. Power Supply Schematic Diagram

A. POWER SUPPLY: (Fig. 8) The power supply consists of three parts:

1. THE AC POWER TRANSFORMER AND FILTER-RECTIFIER CIRCUITRY: The power transformer, T-2, may be connected for either 117 or 234 volt operation as indicated in the schematic. The secondaries of the transformer supply 18 volts at 1 ampere and 117 volts at 5 ma. The output of the 18 volt winding is full-wave rectified by D203 and D204 and filtered by C202, C203 and R202. The dc voltage developed across C203 is approximately 20 volts. Neither terminal is grounded since the minus terminal of the regulator is grounded at the emitter terminal of Q1.

The output from the 117 v winding is half-wave rectified by D201 and filtered by C201. R201 is a dropping resistor for zener diode D202. This diode is connected between ground and the supply side of the load resistor for transistor Q4. The purpose of this connection will be discussed below.

2. THE SUPER-REGULATED 12 VOLT SUPPLY: (Fig. 9) The unregulated 20 volts dc obtained from rectifiers and the transformer is applied to a solid state regulator consisting of Q1 through Q6 and D202, D205, and D206. Q5 and Q6 form a differential amplifier which compares the voltage across the output of the regulator (C205 is across the output) via divider R210 and R209 to the voltage supplied by zener reference diode D205. If the voltages at the bases of Q5 and Q6 are not equal, the collector voltage of Q5 changes. This change is further amplified by Q4, Q3 and Q2. The signal is finally applied to the base of the series element in the regulator Q1. The signal is always of such magnitude and phase that output voltage is instantaneously brought back to 12 volts. RF-14 is a forward biased diode which sets the emitter voltage of Q4. The collector load resistor of Q4, R205, is returned to minus 10 volts supplied by zener, D202. This extra regulated voltage permits Q4

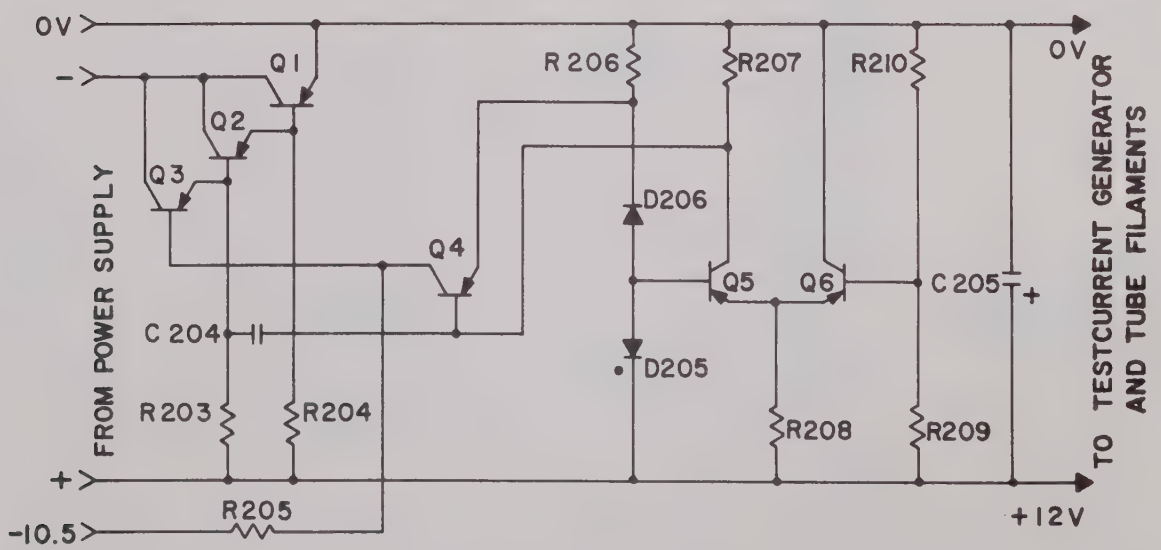


Figure 9. Super Regulated 12 Volt Supply Schematic Diagram

to operate at much higher gain than if the collector load were returned to the unregulated side of the supply and permits linear operation of Q4 with widely varying input voltages. This connection makes an important contribution to the performance of the power supply. Q3 and Q2 are cascaded emitter followers whose function is to increase the current gain of the series transistor, Q1. R203 and R204 are added to the circuit to provide stability at high temperatures since they make available a back-bias current equal to the leakage current of the series transistors at a temperature of approximately 80°C. C204 prevents high frequency oscillation of the power supply. The twelve volts at the output of the regulator powers the filaments of V1 and V2 and the pilot lamp DS-1.

3. 40 CPS TRANSISTOR STATIC INVERTER CIRCUIT: (Fig. 10) A portion of the regulated 12 volt power is also used as the supply for a dc converter consisting of the following parts: Transformer T3, transistors Q7 and Q8, diodes D207 and D208, capacitors C206 and C207, and resistors R211, R212 and R213. The operation is as follows: Transistors Q7 and Q8 are connected across the 12 volt supply through their emitters and the center-tap of the 12 volt winding of T3. The bases receive positive feed-back from another winding on T3. The phasing is such that one transistor is driven hard on while the other is cut off. This cycle lasts until the core of T3 reaches saturation. At this point the transformer can no longer keep the on transistor fully conducting and its collector current decreases. This causes the polarity of the feed-back winding to change and the transistor which was cut off now conducts and the conducting transistor is cut off. The frequency of oscillation is controlled by the transformer constants. In this case the frequency was picked to be 40 cps. The ten volts rms secondary winding is used to provide the test signal and provides a 20 volt peak-to-peak square-wave which is used with series resistors R128 through R139 to provide the proper test current for each range. Diodes D101 and D102 limit the output voltage when the current leads are open circuited.

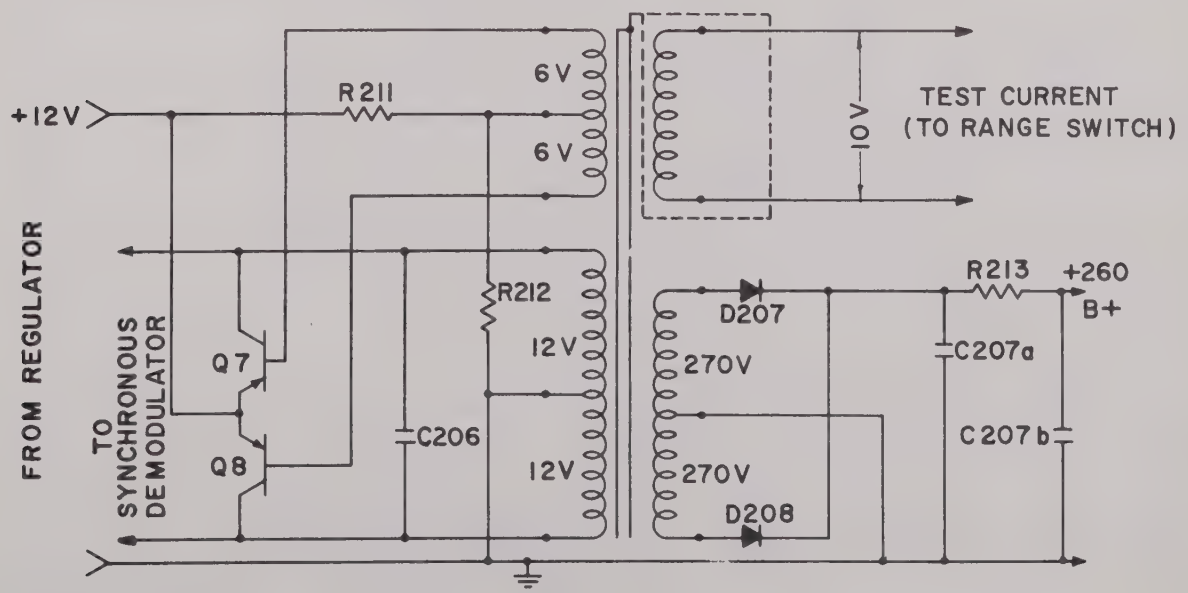


Figure 10. Test Current Generator Schematic Diagram

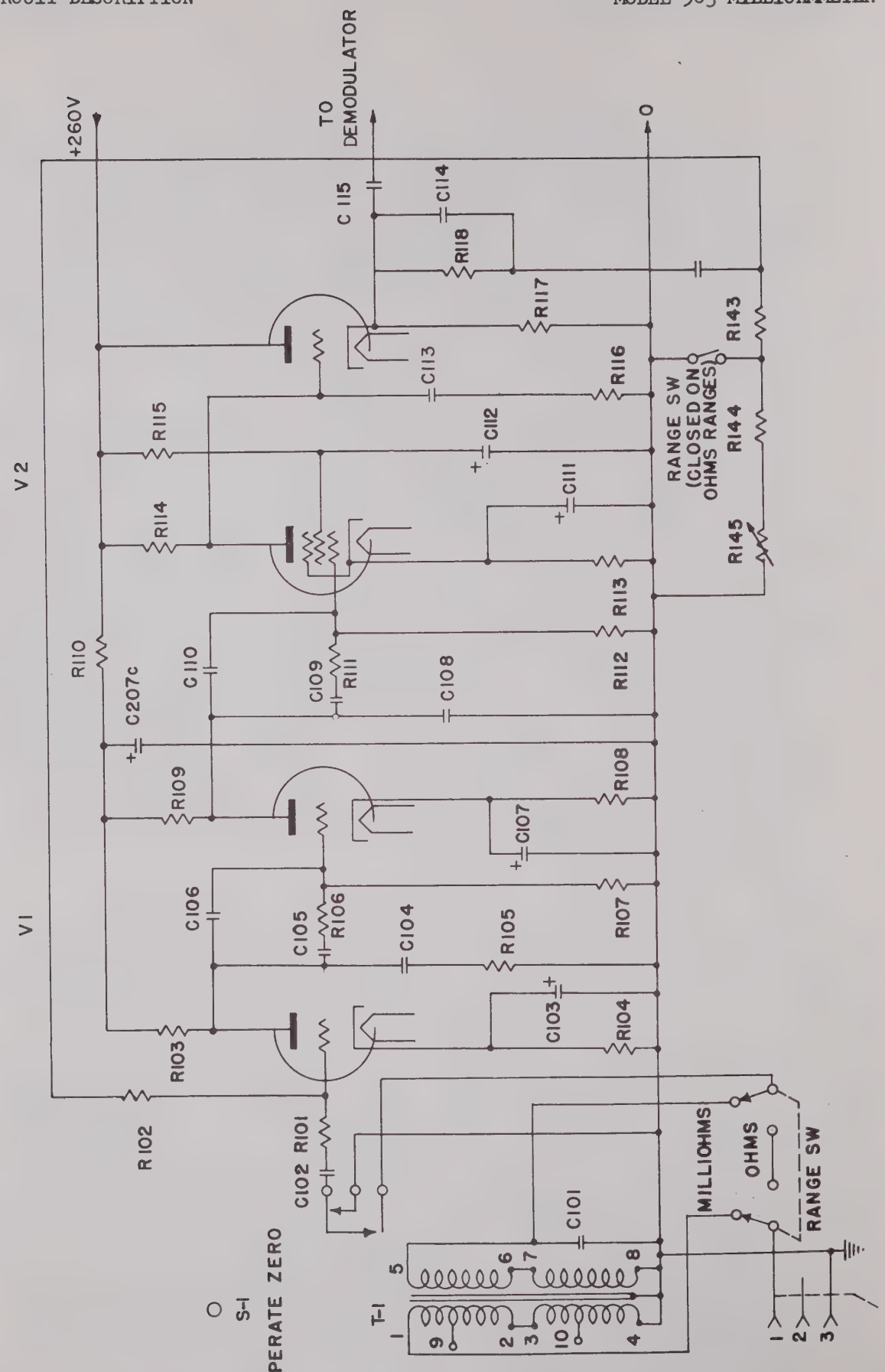


Figure 11. AC Amplifier Schematic Diagram

The 270 volt winding provides a B+ of 260 volts for the vacuum tube amplifier. The signal is rectified by D207 and D208 and filtered by C207 a and b and R213.

Since the stability of the converter circuit depends only on the stability of the twelve volt power supply, very close regulation is obtained for all potentials used in the circuit. Consequently line voltage variations from 100 to 130 volts have no effect on the instrument.

B. TEST CURRENT GENERATOR: (Fig. 10) As mentioned above, the test current is derived from the 10 volt winding of T-3. Since Q7 and Q8 bottom on each half cycle, the amplitude stability of the signal depends only on the 12 volt supply, and is therefore as stable as the well-regulated 12 volt supply. The circuit is not particularly critical as to frequency or wave-form. However, a nearly perfect square-wave is generated and the frequency is stable to better than a few percent.

The current signal is varied to provide the change in range except between 300 milliohms and 1 ohm where the input transformer is removed from the circuit. The variation is accomplished by switching resistors R128 through R139 with each current range. R140 through R142 are used in conjunction with R128 to keep a constant load on the current source winding to insure a high order of accuracy. Diodes D101 and D102 limit the open-circuit voltage in the current leads to plus or minus 0.5 volts.

C. THE AC VACUUM-TUBE VOLTMETER: (Fig. 11) On the Milliohm Ranges the input signal passes through transformer T-1. This transformer has approximately a 70:1 step-up ratio and improves the impedance match between the voltage signal and the input grid by a factor of 5000:1. On the ohm ranges, where a larger signal is obtainable, the transformer is switched out so that its input impedance will not shunt the resistance being measured. Accordingly, on the Milliohm ranges, the input resistance is about 200 ohms. On the Ohms ranges, the input resistance is one megohm.

The input signal is fed into the input of the amplifier either through T1 or around it, depending on range, through S1, the OPERATE-ZERO switch. This switch is of the make-before-break variety to prevent switching transients. Following the switch is C102, the input blocking capacitor and R101, the input resistor of the feed-back network. R102 connects the feed-back signal to the input grid so that the input grid signal is the difference between the input signal and the feed-back signal or, as it is usually termed, the error signal. The error signal is amplified by a standard three stage ac amplifier consisting of V1 and V2a. V2b is an output cathode-follower which drives the feed-back loop, R118, R143, R114 and R115; and the meter and output circuits.

The gain of the amplifier is varied slightly to compensate for the absence or presence of the input transformer by shunting R114 and R145 across R143 in the Milliohm position. The MILLIOHM TRIM control is used to calibrate the milliohm ranges. The divided output of R118 and R143 through R145 is applied to R102 and returned to the input, completing the feed-back loop. A feed-back factor of 40 db assures high gain stability. The fact that all potentials used in the amplifier are closely regulated, also helps assure a high degree of gain stability and complete freedom from line bounce.

The amplifier is stabilized against low frequency oscillation by two sets phase-advance interstage couplings, C106, C105, R106 and R107 between the two halves of V1 and by C110, C109, R111 and R112 between V1b and V2a. Each network introduces an appropriate attenuation and phase lead to prevent oscillation and give adequate phase margin. C104, R105; C108; and C113 and R116; are individual high-frequency oscillation stoppers.

D. THE SYNCHRONOUS DEMODULATOR, METER AND OUTPUT: (Fig. 12) The output of V2b is coupled through C115 and R119 to a demodulator bridge circuit consisting of D103 through D106. The bridge is driven through R146 and R147 from the collectors of Q7 and Q8. Since the center tap of the collector winding is at ground, the drive signal is balanced to ground. When the junction of D103 and D105 is positive with respect to the junction of D104 and D106, the diodes are conducting and the junction between R119 and R120 is effectively grounded. When the polarity is reversed, the bridge is open circuited. Therefore, the signal is rectified in this manner. The output travels through R120, R121 and then is split. Part of the current drives the meter and the remainder the output. R121 is the calibration control. It is located on the front panel. On the CAL position of the range switch, R127 is switched in and this potentiometer is used to correct the meter reading if necessary. R125 allows calibration of the recorder terminal.

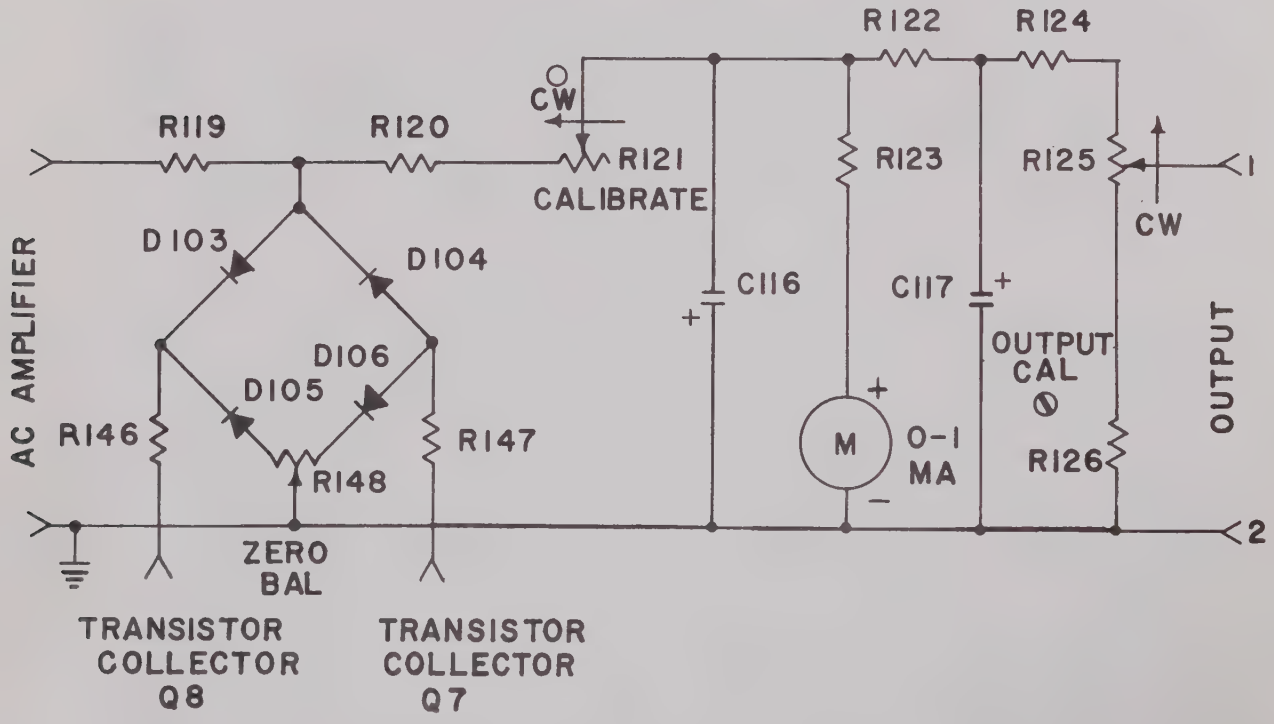


Figure 12. Synchronous Demodulator Meter - Output

SECTION VI - SERVICING INFORMATION

The Model 503 should not require periodic maintenance. Occasional verification of either the calibration (Section IV-C) and the dc balance (Section VI-E) should reveal any need for adjustment. If difficulty is encountered, read completely the following material:

A. Trouble Shooting Guide

Servicing is quite straight forward as the 503 employs only two vacuum tubes and eight transistors, all of which are conservatively operated within their ratings. No matched or critically selected components are used.

The usual caution should be observed when soldering to the printed circuit board as excessive heat will damage the board.

In servicing, bear in mind all operating voltages are obtained from the 12 volt transistor regulator, either directly or through the transistor inverter.

Reference should be made to Circuit Schematic DR 146280 for voltage values and other circuit parameters.

In case of complete failure to operate, the fuse, line cord and power source should all be checked. If these are all found satisfactory, use the following detailed service procedure to isolate the trouble:

1. POWER SUPPLY:

   a. THE AC POWER TRANSFORMER AND FILTER RECTIFIER CIRCUITRY (Figure 8): Set the RANGE SWITCH to the 3 milliohm position with ZERO-OPERATE switch in ZERO position. Remove transistor Q-1 from the circuit and measure the voltage across C203. (See schematic notes for recommended type VTVM). If approximately 25 volts dc is indicated, this portion of the circuit is in proper working-order. Note that neither terminal of C203 is grounded.

      Measure voltage across D202, which should be between -9 to -12 volts with respect to ground. If not, check diodes D201 and D202.

   b. THE SUPER REGULATED 12 VOLT SUPPLY (See Figure 9): Replace transistor Q-1 in the circuit. Determine that the regulated 12 volts across C205 does not vary more than 5 mv with line voltages from 105 volts to 125 volts. Use a variable autotransformer to supply the line voltage. (General Radio Variac)

      If no voltage is present or the 12 volts are not regulated, check components in this portion of the circuit.

2. 40 CPS TRANSISTOR INVERTER (Figure 10): With the range switch set at 3 milliohms, connect the current test leads to an oscilloscope. Observe a 40 cps square wave with a peak to peak amplitude of about 20 volts. If this is present, measure +260 volts dc across C207b. If no square wave is observed, or the B+ is absent, check the components in this portion of the circuit.

NOTE: FOR SECTIONS 3 AND 4 THE RANGE SWITCH SHOULD BE IN CAL POSITION WITH THE ZERO-OPERATE SWITCH IN THE OPERATE POSITION.

3. THE AC VACUUM TUBE VOLTMETER. (Figure 11): Be sure both vacuum tube filaments are heated and the pilot lamp is lit. Since the pilot lamp is in parallel with the filament of V1 and the combination is in series with the filament of V2 across the 12 volt regulator, some service information is provided by its brilliance. If it lights normally, it may be assumed the supply is working properly. If it is brighter than normal, V1 is probably burned out. If the lamp is not lit, either V2 is burned out, or the pilot itself is open. The instrument will operate without the pilot lamp, but since the life of V1 will be reduced, it should be replaced.

If it is determined the tubes are operating properly, proceed as follows: Measure at the junction of C102 and R101 a 4 millivolt peak to peak square wave. This indicates the test current is properly reaching the amplifier through the range switch. Should there be no signal, or one of improper magnitude, inspect the range switch for faulty operation or component failure.

Next, check the voltage between pin 8 of V2 and ground. This should be a square wave voltage of about 10 volts peak to peak. A distortion in/or absence of this signal indicates a faulty AC amplifier.

4. SYNCHRONOUS DEMODULATOR - METER OUTPUT (Figure 12): Connect an oscilloscope to the junction of R-119 and R-120 and compare this wave form with Figure 13.

Figure 13

A distortion or absence of this wave form is an indication of a faulty demodulator.

B. CALIBRATION: The procedure of Section IV-C calibrates the 503 on the 1000 range. Other ranges should be within specification once this range is properly calibrated. If the user wishes to further verify the CALIBRATION, or to calibrate for a given range or point, the following procedures are recommended:

1. OHM RANGES: A standard resistor of at least 0.05% accuracy is recommended. The standard should be selected to 3/4 of full scale of range in question, or to the value of the measurement to be made. The slotted control on the front panel will adjust the meter needle for proper deflection.

2. MILLIOHM RANGES: To calibrate the milliohm ranges, an appropriate low value standard resistor is required. Leeds & Northrup Type 4221-B, 100 milliohms; Type 4222-B - 10 milliohms; and Type 4223-B, 1 milliohm are all suitable. Using one of these resistors or their equivalent, adjust the "MILLIOHM CAL" (Figure 14) for the proper meter reading.

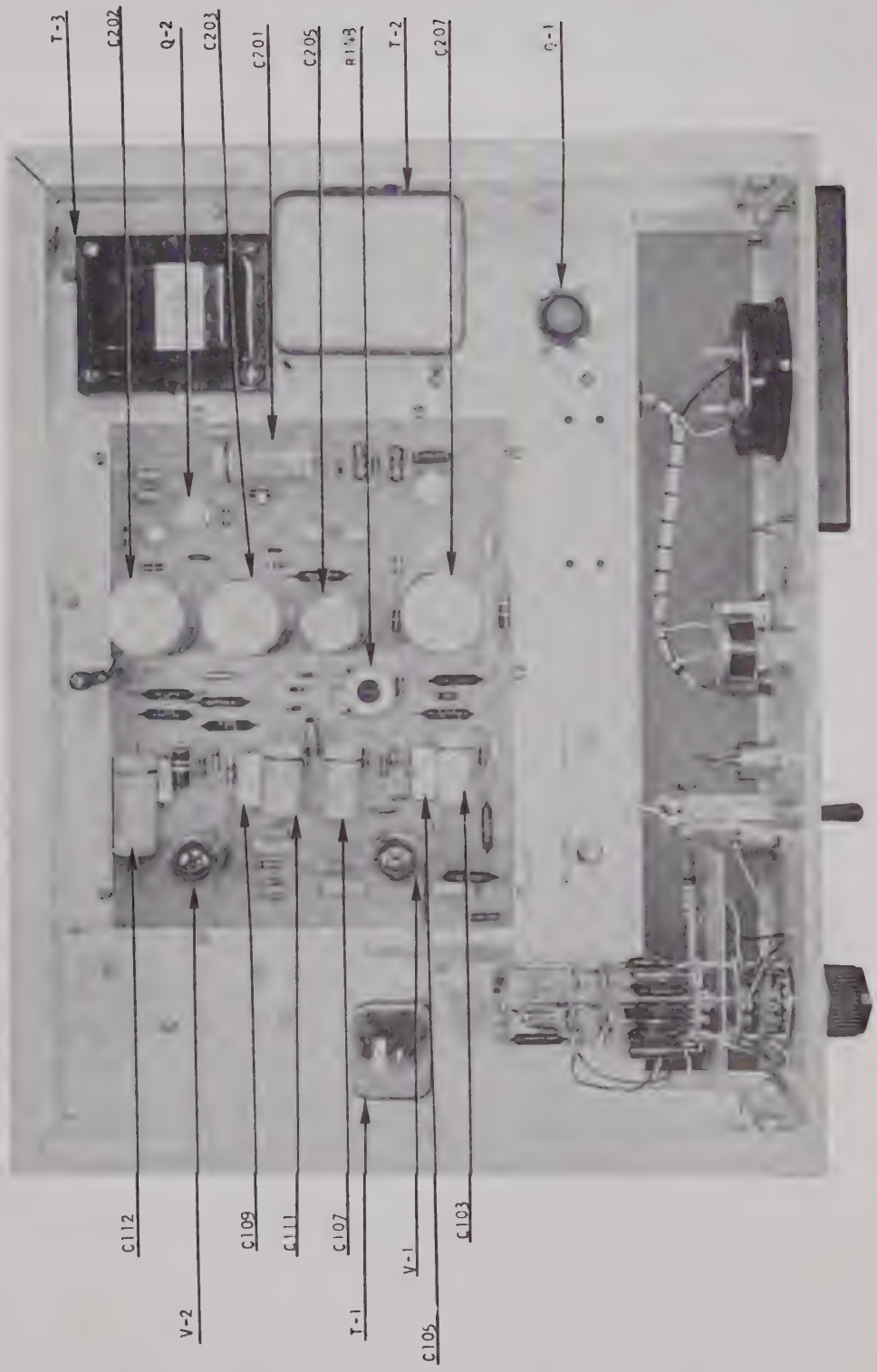


FIGURE 14. Model 503 Internal Components Locations (Top Removed).

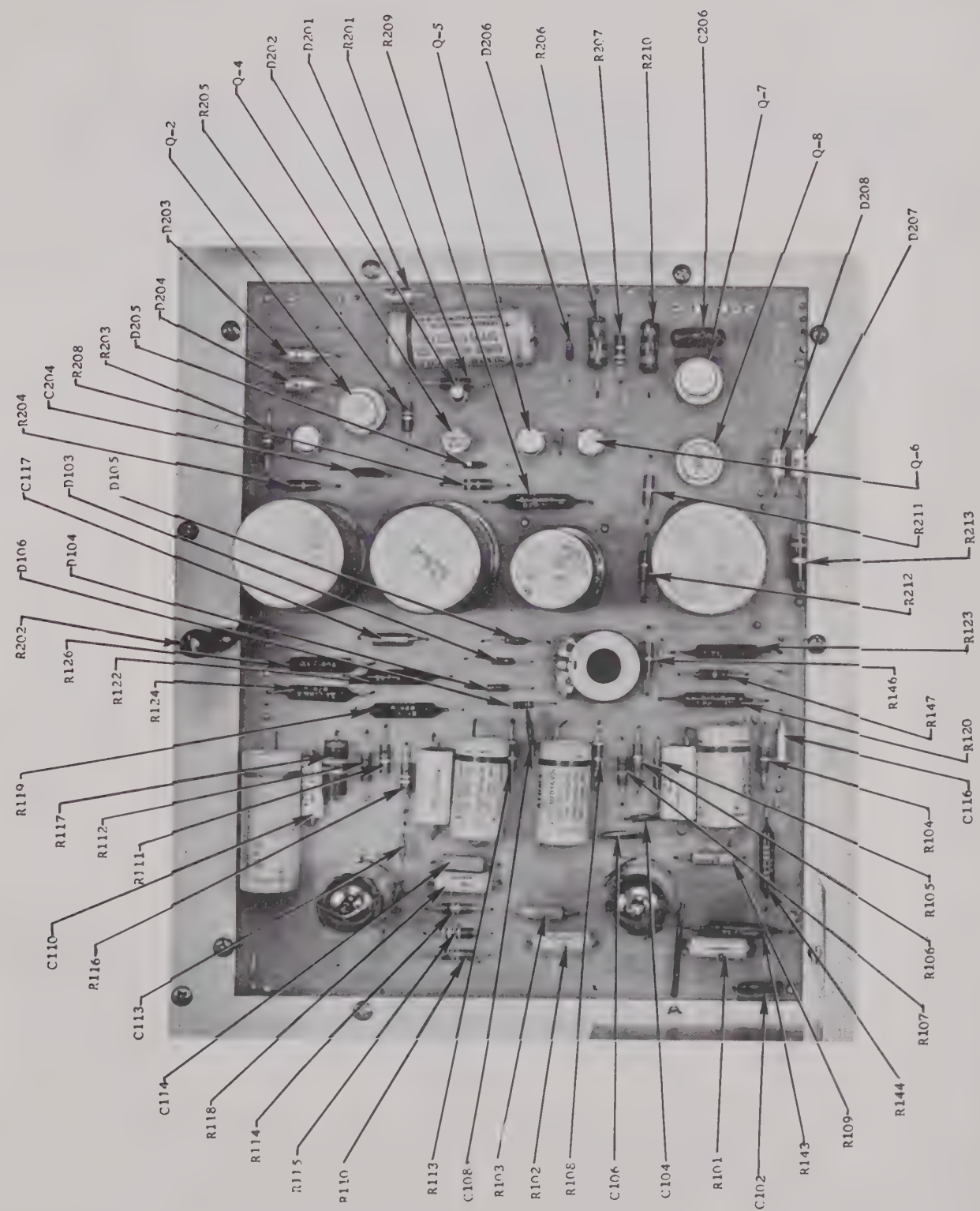


FIGURE 15. Location of Printed Circuit Board Components

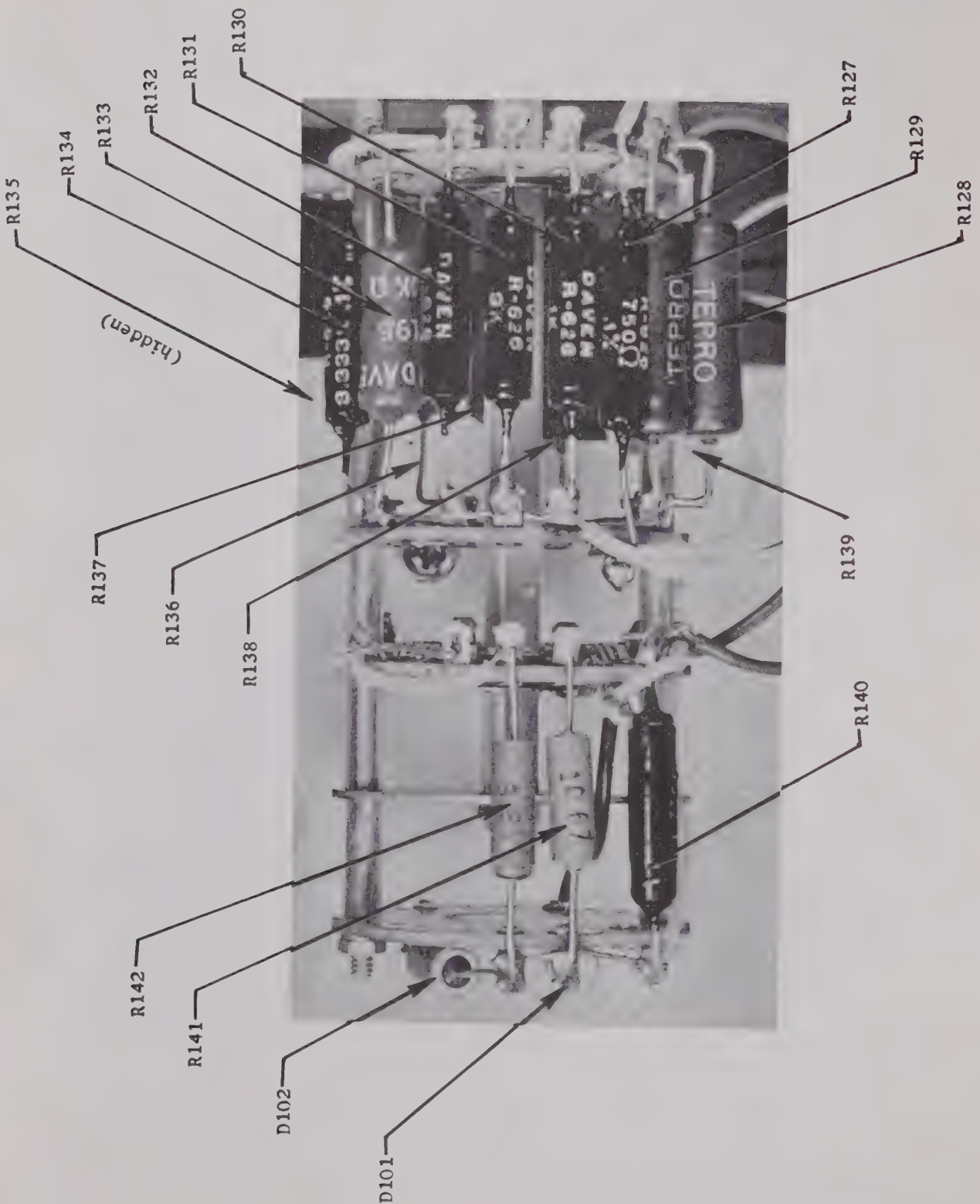


FIGURE 16. Location of Range Switch Components

SECTION 7. REPLACEABLE PARTS

7-1. REPLACEABLE PARTS LIST. The Replaceable Parts List describes the components of the Models 503 and 503C Milliohmmeters and 5031 Current and Voltage Leads. The List gives the circuit designation, the part description, a suggested manufacturer, the manufacturer's part number and the Keithley Part Number. The name and address of the manufacturers listed in the "Mfg. Code" column are contained in Table 6.

7-2. HOW TO ORDER PARTS.

a. For parts orders, include the instrument's model and serial number, the Keithley Part Number, the circuit designation and a description of the part. All structural parts and those parts coded for Keithley manufacture (80164) must be ordered from Keithley Instruments, Inc. In ordering a part not listed in the Replaceable Parts List, completely describe the part, its function and its location.

b. Order parts through your nearest Keithley distributor or the Sales Service Department, Keithley Instruments, Inc.

amp	ampere	Mfg.	Manufacturer
		MtF	Metal Film
CbVar	Carbon Variable	Mil. No.	Military Type Number
CerD	Ceramic, Disc	My	Mylar
Comp	Composition		
CompV	Composition Variable	Ω	ohm
DCb	Deposited Carbon		
		p	pico (10^{-12})
EMC	Electrolytic, metal cased		
ETB	Electrolytic, tubular	μ	micro (10^{-6})
ETT	Electrolytic, tantalum		
		v	volt
f	farad	Var	Variable
		w	watt
k	kilo (10^{3})	WW	Wirewound
M or meg	mega (10^{6}) or megohms	WWVar	Wirewound Variable
m	milli (10^{-3})		

TABLE 5. Abbreviations and Symbols.

MODELS 503, 503C REPLACEABLE PARTS LIST

(Refer to Schematic Diagram 14628D for circuit designations.)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C101	.01 μf	50 v	My	84411	601PE	C41-.01M	
C102	0.1 μf	50 v	My	84411	601PE	C41-0.1M	
C103	100 μf	15 v	ETB	72699	TD100-15	C11-100M	
C104	220 pf	1000 v	CerD	72982	831X5R221K	C22-220P	
C105	1 μf	200 v	My	13050	107-21	C66-1M	
C106	.005 μf	1000 v	CerD	72982	811Z5V502P	C22-.005M	
C107	100 μf	15 v	ETB	72699	TD100-15	C11-100M	
C108	.02 μf	1000 v	CerD	72982	841Z5V203P	C22-.02M	
C109	1 μf	200 v	My	13050	107-21	C66-1M	
C110	.047 μf	200 v	My	14655	WMF2S47	C66-.047M	
C111	100 μf	15 v	ETB	72699	TD100-15	C11-100M	
C112	20 μf	250 v	ETB	56289	TVA1508	C27-20M	
C113	.002 μf	1000 v	CerD	72982	801Z5V202P	C22-.002M	
C114	270 pf	500 v	Mica	84171	DM15-271J	C21-270P	
C115	10 μf	200 v	PMC	72354	X10316	C69-10M	
C116	56 μf	6 v	ETT	05397	K56-J6KS	C70-56M	
C117	56 μf	6 v	ETT	05397	K56-J6KS	C70-56M	
C201	20 μf	250 v	ETB	56289	TVA1508	C27-20M	
C202	500 μf	50 v	EMC	14655	AA0160	C57-500M	
C203	500 μf	50 v	EMC	14655	AA0160	C57-500M	
C204	.01 μf	1000 v	CerD	72982	811Z5V103P	C22-.01M	
C205	500 μf	25 v	EMC	14655	AA0120	C58-500M	
C206	0.22 μf	50 v	My	84411	601PE	C41-0.22M	
C207	40-40-20μf	450 v	EMC	56289	TVL3786	C33-40/40/20M	

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D101	Silicon	1N3253	02735	RF-20	
D102	Silicon	1N3253	02735	RF-20	
D103	Silicon	1N645	01295	RF-14	
D104	Silicon	1N645	01295	RF-14	
D105	Silicon	1N645	01295	RF-14	
D106	Silicon	1N645	01295	RF-14	
D107	Silicon	1N645	01295	RF-14	
D201	Silicon	1N3255	02735	RF-17	
D202	Zener	1N715	12954	DZ-22	

DIODES (Cont'd)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D203	Silicon	1N1563A	04713	RF-19	
D204	Silicon	1N1563A	04713	RF-19	
D205	Zener	1N936	04713	DZ-5	
D206	Silicon	1N645	01295	RF-14	
D207	Silicon	1N3256	02735	RF-22	
D208	Silicon	1N3256	02735	RF-22	
D209	Silicon	1N645	01295	RF-14	

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
DS-1	Pilot Light Assembly, Red lens (Mfg. No. 5100)	72765	PL-5R	
---	Bulb, Miniature bayonet base (Mfg. No. 47)	08804	PL-4	
F1 (117 v)	Fuse, 0.5 amp, (Mfg. No. 312.500)	75915	FU-6	
F1 (234 v)	Fuse, 0.25 amp, (Mfg. No. 3120.25)	75915	FU-9	
---	Fuse Holder (Mfg. No. 342012)	75915	FH-3	
J1	Receptacle, VOLTAGE (Mfg. No. XLR-3-32)	71468	CS-71	
J2	Receptacle, CURRENT (Mfg. No. XLR-3-32)	71468	CS-71	
---	Jack, Mate of J1 and J2 (Mfg. No. XLR-3-11C)	71468	CS-72	
J3	Receptacle, Microphone, OUTPUT (Mfg. No. 80PC2F)	02660	CS-32	
---	Plug, Microphone, Mate of J3 (Mfg. No. 80MC2M)	02660	CS-33	
J4 (c)	Receptacle, Output (Mfg. No. 126-221)	02660	CS-81	
J5 (c)	Same as J4, but does not have jumper			
---	Plug, Mate of J4 and J5 (Mfg. No. 126-220)	02660	CS-82	
K1 (c)	Relay, SPDT	80164	RL-3	
M1 (a)	Meter	80164	ME-39	
M1 (c)	Contact Meter	80164	ME-42	
P1	Power Cord Set, 6 feet (Mfg. No. 4638-13)	93656	CO-5	
---	Cable Clamp (Mfg. No. SR-6P-1)	28520	CC-4	

(a) Used only on Model 503.
(c) Used only on Model 503C.

MISCELLANEOUS PARTS (Cont'd)

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
S1	Switch, SPDT, OPERATE - ZERO (Mfg. No. 3003DL)	82389	SW-59	
S2	Rotary Switch less components, Range	80164	SW-114	
---	Switch Assembly with components, Range	80164	14722B	
---	Knob Assembly, Range Switch	80164	15363A	
S3	Toggle Switch, DPDT, ON (Mfg. No. 20905-FR)	04009	SW-14	
S4 (c)	Pushbutton Switch (Mfg. No. 202)	82389	SW-35	
T1	Transformer, Input	80164	TR-53	
T2	Transformer, Power	80164	TR-59	
T3	Transformer, Inverter	80164	TR-55	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R101	1 MΩ	1%, 1/2 w	MtF	07716	MECT-8	R53-1M	
R102	1 MΩ	1%, 1/2 w	MtF	07716	MECT-8	R53-1M	
R103	470 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-470K	
R104	4.7 kΩ	10%, 1/2 w	Comp	01121	EB	R1-4.7K	
R105	12 kΩ	10%, 1/2 w	Comp	01121	EB	R1-12K	
R106	10 MΩ	10%, 1/2 w	Comp	01121	EB	R1-10M	
R107	1 MΩ	10%, 1/2 w	Comp	01121	EB	R1-1M	
R108	4.7 kΩ	10%, 1/2 w	Comp	01121	EB	R1-4.7K	
R109	470 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-470K	
R110	15 kΩ	10%, 1/2 w	Comp	01121	EB	R1-15K	
R111	10 MΩ	10%, 1/2 w	Comp	01121	EB	R1-10M	
R112	1 MΩ	10%, 1/2 w	Comp	01121	EB	R1-1M	
R113	470 Ω	10%, 1/2 w	Comp	01121	EB	R1-470	
R114	100 kΩ	10%, 1/2 w	Comp	01121	EB	R1-100K	
R115	390 kΩ	10%, 1/2 w	Comp	01121	EB	R1-390K	
R116	10 kΩ	10%, 1/2 w	Comp	01121	EB	R1-10K	
R117	10 kΩ	10%, 2 w	Comp	01121	HB	R3-10K	
R118	1 MΩ	1%, 1/2 w	MtF	07716	MECT-8	R53-1M	
R119	1 kΩ	1%, 1/2 w	WW	01686	E-30	R58-1K	
R120	1.8 kΩ	1%, 1/2 w	WW	01686	E-30	R58-1.8K	

(c) Used only on Model 503C.

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R121	1 kΩ	10%, 3 w	WWVar	37942	R1000L	RP3A-1K	
R122	2.5 kΩ	1%, 1/2 w	WW	01686	E-30	R58-2.5K	
R123	500 Ω	1%, 1/2 w	WW	01686	E-30	R58-500	
R124	2.5 kΩ	1%, 1/2 w	WW	01686	E-30	R58-2.5K	
R125	200 Ω	10%, 5 w	WWVar	71450	AW	RP3A-200	
R126	700 Ω	1%, 1/2 w	WW	01686	E-30	R58-700	
R127	750 Ω	0.1%, 1/2 w	WW	15909	1252	R70-750	
R128	100.5 Ω	10%, 1/2 w	WW	01686		R72-100.5	
R129	301.5 Ω	10%, 1/2 w	WW	01686		R72-301.5	
R130	1 kΩ	0.1%, 1/2 w	WW	15909	1252	R70-1K	
R131	3 kΩ	0.1%, 1/2 w	WW	15909	1252	R70-3K	
R132	10 kΩ	0.1%, 1/2 w	WW	15909	1252	R70-10K	
R133	30 kΩ	0.1%, 1/4 w	WW	15909	1195	R56-30K	
R134	3.33 kΩ	0.1%, 1/2 w	WW	15909	1252	R70-3.33K	
R135	33.3 kΩ	0.1%, 1/4 w	WW	15909	1195	R56-33.3K	
R136	100 kΩ	0.1%, 1/4 w	WW	15909	1195	R56-100K	
R137	333.3 kΩ	0.1%, 1/4 w	WW	15909	1195	R56-333.3K	
R138	1 MΩ	0.1%, 1/2 w	WW	15909	1252	R57-1M	
R139	3.33 MΩ	0.1%, 1 w	MtF	07716	MEFT-8	R59-3.33M	
R140	50 Ω	1%, 1/2 w	WW	01686	E-30	R58-50	
R141	11.1 Ω	1%, 1/2 w	DCb	79727	CFE-15	R12-11.1	
R142	3.33 Ω	1%, 1/2 w	DCb	79727	CFE-15	R12-3.33	
R143	500 Ω	1%, 1/2 w	WW	01686	E-30	R58-500	
R144	235 Ω	1%, 1/2 w	WW	01686	E-30	R58-235	
R145	100 Ω	10%, 5 w	WWVar	71450	AW	RP3A-100	
R146	1 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1K	
R147	1 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1K	
R148	100 Ω	30%, 1/2 w	CompV	71450	45	RP12-100	
R201	27 kΩ	10%, 1 w	Comp	01121	GB	R2-27K	
R202	1.5 Ω	5%, 10 w	WW	94310	FR-10	R5-1.5	
R203	10 kΩ	10%, 1/2 w	Comp	01121	EB	R1-10K	
R204	680 Ω	10%, 1/2 w	Comp	01121	EB	R1-680	
R205	10 kΩ	10%, 1/2 w	Comp	01121	EB	R1-10K	
R206	300 Ω	1%, 1/2 w	WW	01686	E-30	R58-300	
R207	3.9 kΩ	10%, 1/2 w	Comp	01121	EB	R1-3.9K	
R208	3.9 kΩ	10%, 1/2 w	Comp	01121	EB	R1-3.9K	
R209	900 Ω	1%, 1/2 w	WW	01686	E-30	R58-900	
R210	*300 Ω	1%, 1/2 w	WW	01686	E-30	R58-300	
R211	100 Ω	10%, 1/2 w	Comp	01121	EB	R1-100	
R212	1.5 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1.5K	

* Nominal value, factory set.

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R213	3.3 kΩ	10%, 1 w	Comp	01121	GB	R2-3.3K	
R214	1 Ω	1%, 1/2 w	DCb	79727	CFE-15	R12-1	
R215	1.5 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1.5K	
R216	1 Ω	1%, 1/2 w	DCb	79727	CFE-15	R12-1	

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q1	2N1535	04713	TG-7	
Q2	2N1183	02735	TG-11	
Q3	2N1381	01295	TG-8	
Q4	2N1381	01295	TG-8	
Q5	2N1381	01295	TG-8	
Q6	2N1381	01295	TG-8	
Q7	2N1183	02735	TG-11	
Q8	2N1183	02735	TG-11	

VACUUM TUBES

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
V1	7025	73445	EV- 7025	
V2	6U8	81453	EV-6U8A	

MODEL 5031 REPLACEABLE PARTS LIST

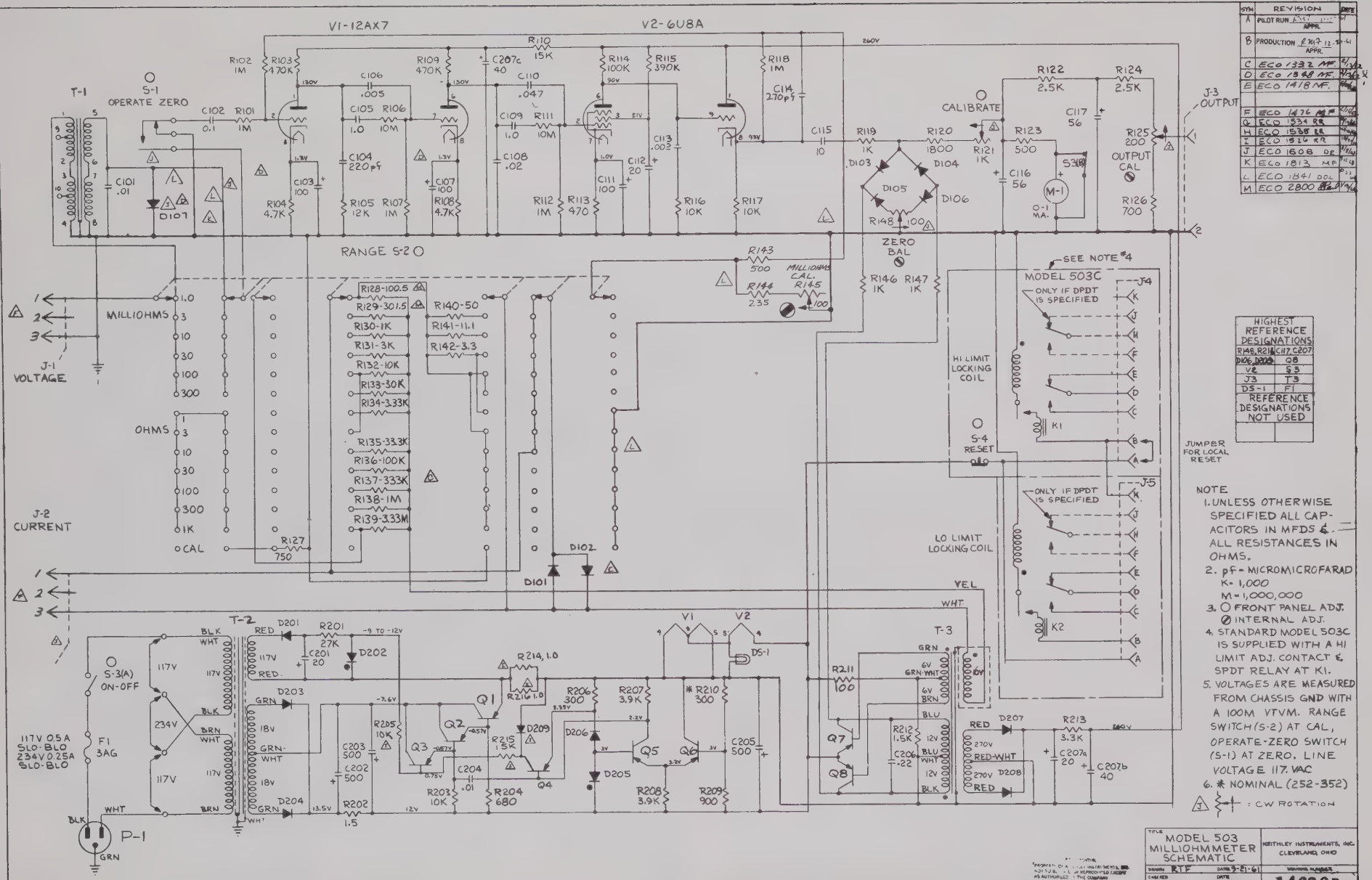
Description	Mfg. Code	Keithley Part No.
Test lead, 48 inches	80164	14731B
Two Alligator Clips (Mfg. Series 60)	76545	AC-1
Jack (Mfg. No. XLR-3-11C)	71468	CS-72

01121	Allen-Bradley Corp. Milwaukee, Wis.	02660	Amphenol-Borg Electronics Corp. Broadview Chicago, Illinois
01295	Texas Instruments, Inc. Semi-Conductor-Components Division Dallas, Texas	02735	RCA Semiconductor and Materials Division of Radio Corp. of America Somerville, N. J.
01686	RCL Electronics, Inc. Riverside, N. J.	04009	Arrow-Hart and Hegeman Electric Co. Hartford, Conn.

TABLE 6 (Sheet 1). Code List of Suggested Manufacturers. (Based on Federal Supply Code for Manufacturers, Cataloging Handbook H4-1.)

04713	Motorola, Inc. Semiconductor Products Division Phoenix, Arizona
05397	Kemet Co. Cleveland, Ohio
07716	International Resistance Co. Burlington, Iowa
08804	Lamp Metals and Components Department G. E. Co. Cleveland, Ohio
12954	Dixon Electronics Corp. Scottsdale, Arizona
13050	Potter Co. Wesson, Miss.
14655	Cornell-Dubilier Electric Corp. Newark, N. J.
15909	Daven Co. Livingston, N. J.
28520	Heyman Mfg. Co. Kenilworth, N. J.
37942	Mallory, P. R., and Co., Inc. Indianapolis, Ind.
56289	Sprague Electric Co. North Adams, Mass.
71450	CTS Corp. Elkhart, Ind.
71468	Cannon Electric Co. Los Angeles, Calif.
72354	Fast John E. and Co. Chicago, Ill.
72699	General Instrument Corp. Newark, N. J.
72765	Drake Mfg. Co. Chicago, Ill.
72982	Erie Technological Products, Inc. Erie, Pa.
73445	Amperex Electronic Co. Division of North American Philips Co., Inc. Hicksville, N. Y.
75042	International Resistance Co. Philadelphia, Pa.
75915	Littelfuse, Inc. Des Plaines, Ill.
76545	Mueller Electric Co. Cleveland, Ohio
79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.
80164	Keithley Instruments, Inc. Cleveland, Ohio
81453	Raytheon Co. Industrial Components Div. Industrial Tube Operation Newton, Mass.
82389	Switchcraft, Inc. Chicago, Ill.
82879	Royal Electric Corp. Pawtucket, R. I.
84171	Arco Electronics, Inc. Great Neck, N. Y.
84411	Good-All Electric Mfg. Co. Ogallala, Nebr.
94310	Tru Ohm Products Div. of Model Engineering and Mfg., Inc. Chicago, Ill.
99942	Hoffman Electronics Corp. Semiconductor Division El Monte, Calif.
93656	Electric Cord Co. Caldwell, N. J.

TABLE 6 (Sheet 2). Code List of Suggested Manufacturers. (Based on Federal Supply Code for Manufacturers, Cataloging Handbook H4-1.)



SYM	REVISION	DATE
A	PILOT RUN APPR.	
B	PRODUCTION APPR.	
C	ECO 1332 MF	
D	ECO 1348 MF	
E	ECO 1418 MF	
F	ECO 1476 MF	
G	ECO 1534 RR	
H	ECO 1538 RR	
I	ECO 1516 RR	
J	ECO 1608 DR	
K	ECO 1813 MF	
L	ECO 1841 DDL	
M	ECO 2800	

HIGHEST REFERENCE DESIGNATIONS	
R148, R216, C117, C207	
D106, D209	Q8
V2	S3
J3	T3
DS-1	F1
REFERENCE DESIGNATIONS NOT USED	

NOTE

1. UNLESS OTHERWISE SPECIFIED ALL CAPACITORS IN MFDS & ALL RESISTANCES IN OHMS.
2. pf = MICROMICROFARAD
   K = 1,000
   M = 1,000,000
3. O FRONT PANEL ADJ.
   ⊘ INTERNAL ADJ.
4. STANDARD MODEL 503C IS SUPPLIED WITH A HI LIMIT ADJ. CONTACT & SPDT RELAY AT K1.
5. VOLTAGES ARE MEASURED FROM CHASSIS GND WITH A 100M VTVM. RANGE SWITCH (S-2) AT CAL, OPERATE-ZERO SWITCH (S-1) AT ZERO. LINE VOLTAGE 117 VAC
6. * NOMINAL (252-352)

: CW ROTATION

TITLE: MODEL 503 MILLIOHMMETER SCHEMATIC

KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO

DRAWN RTF DATE 9-21-61

CHECKED DATE

APPROVED DATE 11-17-61

DRAWING NUMBER 14628D

REPAIR AND CALIBRATION FORM

For repair or calibration, please fill out this form and return it with your instrument to:

Sales Service Department
Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

R-
Do not write in this space.

User's Name _____ Telephone _____ Ext. _____
Company _____ Address _____
Division _____ City _____ State _____ Zip _____
Date _____ Model No. _____ Serial No. _____

1. Reason for Return
   - ☐ Repair and Recalibration
   - ☐ Recalibration only (No report, except as specified in item 4 on reverse)*

   *If repairs are necessary to meet specifications, they will be in addition to the calibration.

2. Calibration Report Desired
   - ☐ Report of Calibration Certified Traceable to N.B.S.
   - ☐ Calibration Report
   - ☐ Certificate of Compliance
   - ☐ None

   (for details, see reverse side of this form)

3. To help repair the instrument, briefly describe the problem: _____

4. Is the problem ☐ Constant ☐ Intermittant

   Under what conditions does the problem occur:

   a) Control setting _____
   b) Approx. Temperature _____ °F
   c) Approx. Temperature variation ± _____ °F
   d) Approx. Humidity (high, medium, low) _____
   e) Line voltage _____
   f) Other (such as line transients, line variations, etc.) _____

5. Please draw a block diagram of the system using the Keithley. List any other pertinent data which can help in the repair. Include charts or other data if available.

   Signal Source _____
   Source Impedance _____
   Readout Device:
   - ☐ Recorder
   - ☐ Oscilloscope
   - ☐ Other
   - ☐ None

   Lengths & Types of Connecting Cables _____

6. What repairs or modifications have been made on this instrument which are not on file with the Keithley Repair Department? _____

7. Please enclose any other pertinent data and charts which you feel might help the Repair and Calibration Department

_____ Signature _____ Title

1267

CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS.

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

1. Report of Calibration Certified Traceable to the National Bureau of Standards.

This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

As of 12/1/67 the Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	$325	Model 5155 (Complete Set)	$265
Model 260	$220	Model 5155-10^8	$ 45
Model 261	$280	Model 5155-10^9	$ 45
Model 515	$520	Model 5155-10^{10}	$ 45
Model 630	$250	Model 5155-10^{11}	$ 55
Model 660A	$200	Model 5155-10^{12}	$ 55
Model 662	$250	Model 5155-10^{13}	$ 75

2. Calibration Report.

This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

This report is available for any instrument in our line. As of December 1, 1967, only the following price has been established for this report:

Model 261 . . . . . $50

Prices for other units can be estimated upon request.

3. Certificate of Compliance.

This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The $50 charge is incorporated as part of the normal calibration charge of the Model 261.

4. Recalibration.

This is a recalibration of the instrument according to our factory calibration procedures. The prices for this as of December 1, 1967 are as follows:

Model 260	$75	(No report supplied. A Certificate of Compliance can be had at no charge if requested).
Model 261	$50	(Calibration Report as described in (2) above is supplied. See (3) for explanation).

All other instruments are on a time and material basis for the particular unit involved.

U.S.A. and Canada sales offices

1■ KEITHLEY INSTRUMENTS, INC.
28775 Aurora Road
Cleveland, Ohio 44139
(216) 248-0400

2 KEITHLEY INSTRUMENTS, INC.
5817 Baltimore Boulevard
Riverdale, Maryland 20840
(301) 277-5111

3 KEITHLEY INSTRUMENTS, INC.
101 East Lancaster Avenue
Wayne, Pennsylvania 19087
(215) 687-1170

4 KEITHLEY INSTRUMENTS, INC.
12-94 Plaza Road
Fair Lawn, New Jersey 07410
(201) 797-5440

5 KEITHLEY INSTRUMENTS, INC.
235 Bear Hill Road
Waltham, Massachusetts 02154
(617) 891-4428

6 KEITHLEY INSTRUMENTS, INC.
Pickard Building, Room 140
5858 East Molloy Road
Syracuse, New York 13211
(315) 455-6696

7 KEITHLEY INSTRUMENTS, INC.
6300 North Cicero Avenue
Chicago, Illinois 60646
(312) 545-3690

8 MURPHY & COTA
1106 Burke Street
Winston-Salem,
North Carolina 27101
(919) 724-0750

904 Bob Wallace Avenue
Huntsville, Alabama 35801
(205) 539-8476

712 West Vassar Street
Orlando, Florida 32804
(305) 424-2407

9 JOHN A. GREEN CO.
7118 Envoy Court
Dallas, Texas 75247
(214) 631-7450

3400 Montrose Boulevard
Houston, Texas 77006
(713) 526-2959

P. O. Box 3209
Tulsa, Oklahoma 74101
(918) 742-4657

10 AZTEC ENTERPRISES, INC.
3202 Candelaria Road, N. E.
Albuquerque, New Mexico 87107
(505) 345-3441

3385 S. Bannock
Englewood, Colorado 80110
(303) 761-0101

Salt Lake City, Utah
Zenith 957

11 KEITHLEY INSTRUMENTS, INC.
825 San Antonio Road
Palo Alto, California 94303
(415) 321-5291

12■ KEITHLEY INSTRUMENTS, INC.
15010 Ventura Boulevard
Sherman Oaks, California 91403
(213) 784-1159

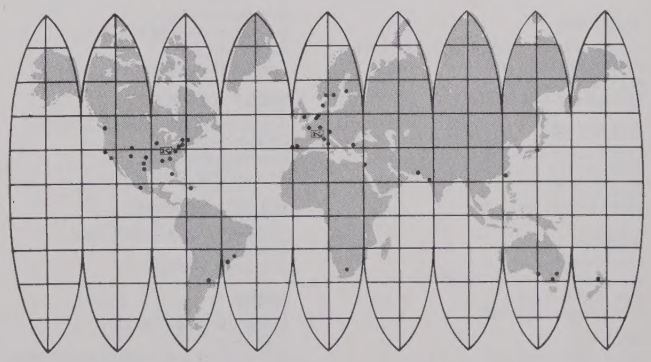
13 AURORA TECHNICAL INDUSTRIES, LTD.
#2-650 Clyde Avenue
West Vancouver, British Columbia
(604) 922-0136

14 NO REPRESENTATIVE
(See 1)

■ Authorized Service Center.

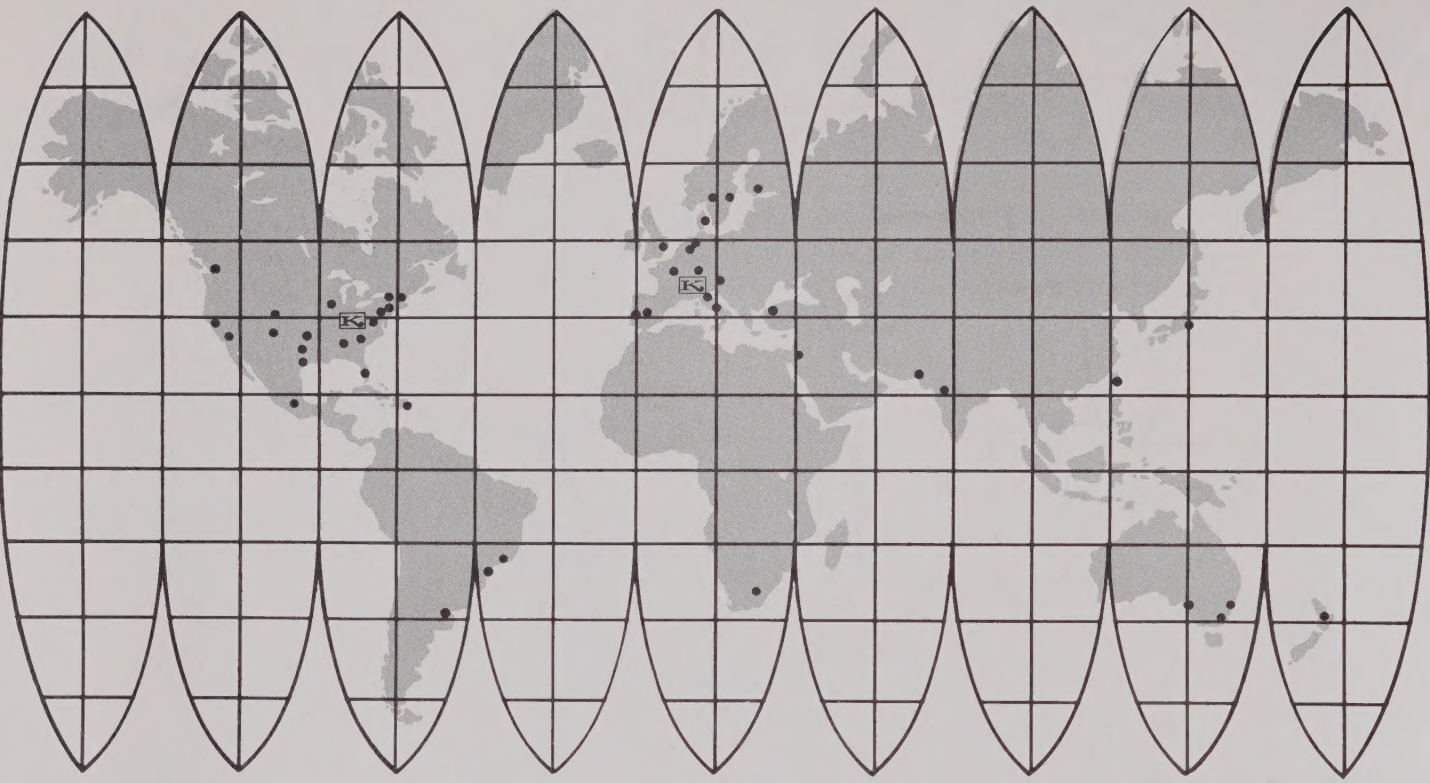
european services

Keithley has a manufacturing facility in Germany and a warehouse and office in Switzerland to provide prompt delivery in the European area. The facilities, staffed by Keithley field engineering personnel, give on-the-spot assistance to your Keithley representative so that he may better serve you. A list of the worldwide Keithley representatives is given on the back.



KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD • CLEVELAND, OHIO 44139
TELEPHONE: (216) 248-0400
TELEX: 98-5469

LITHO IN U.S.A.



international sales offices

ARGENTINA
Coasin S.A.
Virrey del Pino 4071
Buenos Aires
Telephone: 52-3185

AUSTRALIA
Sample Electronics (Aust.) Pty. Ltd.
9-11 Cremorne Street
Richmond, Victoria 3121
Telephone: 42-4757

Sample Electronics (Aust.) Pty. Ltd.
82 Alexander Street
Crows Nest, New South Wales 2065
Telephone: 439-1441

Sample Electronics (Aust.) Pty. Ltd.
171 Gilbert Street
Adelaide, South Australia 5000
Telephone: 517404

AUSTRIA
International Engineering Service
Veitingergasse 159
A-1130 Vienna 13
Telephone: 82-46-732

BELGIUM
Etablissements Miravox, S.p.r.l.
57EF, Avenue d'Auderghem
Brussels 4
Telephone: 35-41-74

BRAZIL
Ambriex, S.A.
Av. Graca Aranha, 226-6°
Rio de Janeiro
Telephone: 427-990

Ambriex, S.A.
Av. Pacaembu,°811
Sao Paulo
Telephone: 52-0655

CHINA
Industrial Electronics
P.O. Box 22423
Taipei, Taiwan
Telephone: 74257

DENMARK
SC Metric A/S
Naerum Hovedgade 121
Naerum
Telephone: (01) 80-42-00

FINLAND
Into O/Y
Meritullinkatu 11
P.O. Box 10153
Helsinki 10
Telephone: 11-123

FRANCE
Ets. Radiophon
148, Avenue Malakoff
F-75 Paris 16°
Telephone: 553-32-50

WEST GERMANY
Keithley Instruments, GmbH.
Postfach 268
D-8000 Munich 49
Telephone: 75-40-41

GREAT BRITAIN
Keithley Instruments Ltd.
P.O. Box 43
Reading, Berks

INDIA
Motwane Private, Ltd.
P.O. Box 1312
127, Mahatma Gandhi Road, Fort
Bombay 1
Telephone: 252337

ISRAEL
Levant X-Ray, Ltd.
P.O. Box 246
Tel-Aviv
Telephone: 821-566

ITALY
Dott. Ing. Mario Vianello
Via Luigi Anelli, 13
I-20122 Milano
Telephone: 553-081

Dött. Ing. Mario Vianello
Via S. Croce in Gerusalemme, 97
Roma
Telephone: 772-941

JAPAN
Toyo Trading Co., Ltd.
P.O. Box 999
5th-7th Floor, Daito Building
No. 2, 1-chome, Hongokucho
Nihonbashi, Chuo-ku, Tokyo
Telephone: 279-0771

MEXICO
Fredin, S.A.
Melchor Ocampo No. 212-505
Mexico 5, D.F.
Telephone: 46-44-21

NETHERLANDS
Peekel, N.V.
Alblasstraat 1
Rotterdam 8
Telephone: (010) 15-27-22

NEW ZEALAND
Sample Electronics (NZ) Ltd.
8, Matipo Street
Onehunga, Auckland
Telephone: 567-356

NORWAY
Morgenstierne & Company
Wessels Gate 6
PB. ST. H. 2613
Oslo
Telephone: 20-16-35

PAKISTAN
Techtronics Corp.
1st Floor, Overseas Chambers
Alamgir Road
Karachi 5
Telephone: 45325

PORTUGAL
Telectra S. A. R. L.
R. Rodrigo da Fonseca 103
Lisboa 1
Telephone: 68-60-72

REPUBLIC OF SOUTH AFRICA
Protea Physical & Nuclear
Instrumentation, Pty. Ltd.
P.O. Box 7793
Johannesburg, T.V.L.
Telephone: 838-8351

SPAIN
Ataio Ingenieros
Enrique Larreta, 12
Madrid 16
Telephone: 235-35-43

SWEDEN
Oltronix AB
Jamtlandgatan 125
pa Vallingby
Stockholm
Telephone: 87-03-30

SWITZERLAND
Seyffer and Company, Inc.
Badenerstrasse 265
CH-8040 Zurich
Telephone: (051) 25-54-11

TURKEY
Mevag
Karakoy Bankalar Caddesi 71-73
Istanbul
Telephone: 49-83-00

YUGOSLAVIA
Belram S. A.
83 avenue des Mimosas
Brussels 15, Belgium
Telephone: 34-33-32

KEITHLEY INSTRUMENTS, S.A.

14, AVENUE VILLARDIN • CH-1009 PULLY, SUISSÉ
TELEPHONE: (021) 28-11-68

KEITHLEY INSTRUMENTS, INC.

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY